kinds of light not liable to be absorbed in notable degree by the yellow pigment. On the whole, it is accordingly found that this pigmentation is subjectively influential only in cases in which the rays in the neighbourhood of the line F play a prominent part, as, for example, in a certain mixture of this blue with red (mentioned on page 354) which, if it looks white when our eyes are directly fixed upon it, will show blue predominant when we look in a slightly different direction.

As far as hitherto-known facts go, it appears very improbable that Hering's theory of dichromasy can be carried through. Nevertheless, further observations in this direction are very desirable. The influence which the colouration of the yellow spot has in individual eyes can be estimated by comparing the appearances of colour-mixtures in the centre of the field of view with their appearances very near the centre. Such comparisons will show with certainty where such influence is present and where it is absent.

The following is a summary, by Prof. Everett, of two passages from the new edition of Helmholtz's "Physiological Optics," which are important as supplementing the foregoing critique of Hering's theory :—

In discussing the results of experiments for determining the exact positions of the three elementary sensations with respect to actual colours, in Newton's diagram or in Lambert's pyramid, Helmholtz represents the results by a triangle with the three elementary sensations at its corners, and with the colours of the spectrum plotted along a curve which lies entirely in the central portion of the triangle. He says, p. 457 :—

"This curve shows that every simple colour excites simultaneously in the trichromic eye the three nerve-elements which are sensitive to light, and excites them with only moderate differences of intensity. If we then hypothetically refer all these excitations to the presence of three photo-chemically alterable substances in the retina, we must conclude that all three of these must have nearly the same limits of sensibility to light, and must show, in the rates of their photo-chemical actions for the different wave-lengths, only secondary variations of moderate amount. Similar variations, arising from the presence of foreign substances, from substitutions of analogous atom-groups, and so on, occur also in other photo-chemically alterable substances as used in photography ; for example, in the different haloid salts of silver."

In a mathematical discussion of colour-blindness, commencing at p. 458, he points out that in dichromic vision there must be a linear relation between the three independent elements of trichromic vision, and in Lambert's colour pyramid there must be a certain line through the vertex, such that any plane drawn through it is a plane of uniform colour. Newton's diagram of colour may be regarded as contained in any plane which cuts the axis of the pyramid ; and it is very important to determine the point in which the above-mentioned line cuts such a plane ; for any line in Newton's diagram that passes through this point is a line of uniform colour to the dichromic vision in question. Experiment shows that it always lies outside the triangle of actual presentable colours.

Addendum.

Prof. Everett adds the following remarks of his own on the present position of the problem of colour-vision :—

On the one hand, it is established, as a fact of experiment, that the excitation of colour-sensation in the normal eye depends upon only three variables, and that their effects are superposable, so as to admit of being expressed by equations of the first degree, otherwise called linear equations. The simplest choice of three variables is that adopted in Young's theory, because it only requires positive values of the variables.

On the other hand, the various colours regarded as subjective appearances do not naturally class themselves under a threefold heading. Yellow does not look as if it consisted of red and green. Colour-sensations as known to us in consciousness are not threefold but manifold.

The two facts taken together seem to imply two successive operations intervening between the incidence of light and the perception of colour. The first operation is threefold, and may consist (as above suggested by Helmholtz) of the photo-chemical decomposition of three different substances. The second operation consists in the effects of the first operation upon a complex organism, and the distinctions of colours as we see them arise out of the nature of this organism.

The number of independent variables required for specifying the condition of a system is a very different thing from the number of well-distinguished states in which the system can exist. For example, the state of a given mass of water-substance is completely determined if its volume and temperature are given, and therefore depends on only two variables. But the number of its well-distinguished states is three. In like manner colour depends on three variables, but the number of well-distinguished colours, besides white, may be said to be seven, namely the six principal colours of the spectrum and purple.

What differences of condition in the organism correspond to these eight distinct appearances in the field of view, and how these different conditions are produced by the three primary excitations, are problems awaiting solution.

AUTOMATIC MERCURIAL AIR-PUMPS.

Of late years, and more especially during the last decade, men of science have devoted much thought and ceaseless energy to the invention of an apparatus which should admit of the automatic working of mercurial air-pumps. Of the numerous inventions brought forward, the ingenious apparatus of Schuller and Stearn are especially deserving of mention.

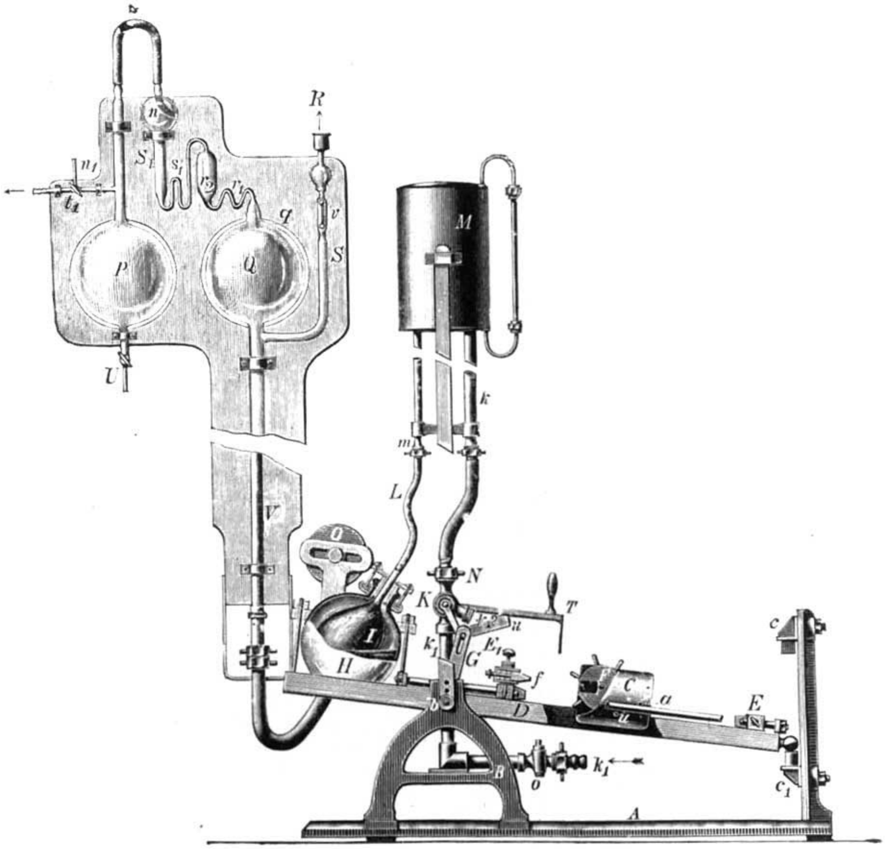
But notwithstanding the present extensive employment of the mercurial air-pump in science as well as in technics these appliances are neither much known, nor have they been used to any great extent, although they are of great importance, and would probably be very advantageous. This may be explained by the fact that they are wanting in the necessary simplicity and trustworthiness, without which the advantages of automatically working mercurial air-pumps are somewhat doubtful.

We shall describe now an apparatus for the perfectly trustworthy and automatic working of mercurial air-pumps, as well as the shape of the glass pump used in connection with it, which, while possessing the greatest possible simplicity, admits of the highest rarefactions hitherto known.

The figure shows the automatic apparatus in connection with an improved Toepler mercurial air-pump. The glass ball H is connected on the one hand by flexible tubes with the pump Q, on the other hand by the tube L with the accumulator M. The water-pipe K runs into the bottom of the accumulator, and by means of a specially-constructed three-way cock K can either be connected with the hydrostatic pressure-pipe K_1 or the discharge-pipe K_2.

If water under pressure is admitted through the tubes k_1, K and k into M, the air contained in M is compressed. This air again exerts a pressure through the tube L on the mercury contained in H, and drives it into the pump Q. As soon as the mercury has risen sufficiently high and the cock K is reversed, the compressed air forces the water out again through k, K, and k_2, and the mercury falls down on account of its own weight out of the pump Q back into the ball H.

The reversing of the three-way cock, and therewith the automatic action of the pump, is effected in the following manner:—The ball H rests on a frame D, revolving about the axis b, and the motion of which is limited by the ledges c and c_1. A lever G is attached to the frame not far from the axis, and by means of a peg, when the balance D reverses its position, also turns the cock. When the ball H is entirely filled with mercury the balance D rests on the upper ledge c. If the pump is set in motion the left side of the balance D becomes lighter in proportion to the amount of mercury forced out of the ball H into the pump, until at last the weight C on the right-hand side becomes heavier, and the balance thereby attains the position shown by the figure. The three-way cock is also reversed by this motion.



Thus, as already described, the water current is now cut off, the water present in M flows out through K_2, and the mercury goes back from the pump Q into the ball H.

During the tipping over of the balance, however, the sliding weight C has run down its inclined plane to a ledge, E, so that it now exerts a pressure on the lever arm. Its momentum is so calculated that the mercury in the pump must have fallen to the point p, and flowed back into the ball H before it again overweighted, and moves back the balance. The weight C then slides back again to the left until it rests against its left ledge, and the play of the pump recommences. It will easily be seen that the height to which the mercury rises in the pump, the mass of the sliding weight being a constant quantity, depends only on its final positions, and that, therefore, the adjusting of the height of the mercury can be easily and accurately done up to a centimetre.

It goes without saying that every mercurial air-pump not provided with cocks can be worked by the apparatus just described. But the improved construction of the Toepler pump, drawn likewise in projection in the figure, has proved to be especially practical. The following is a description of its automatic working:—

If the cock t_1 is connected with an hydrostatic air-pump, the ball Q of the pump and the space R, which is to be evacuated through the tube S, is pumped out up to the tension of the vapour. The mercury then rises in the tube R almost to the height of the barometer above its level in the ball H. If the automatic apparatus is then set in motion, the mercury enters the ball Q and the tube S, thus cutting off the connection with R, while any further rising of the mercury in the tube S is prevented by a glass valve v, it passes through the first V-tube r_1 filling the little vessel r_2 and rises through s_1 into the ball n, driving before it the air which was before shut off in Q. At this moment so much mercury has been forced out of the ball H into the pump Q, that the balance is turned, the mercury flows back out of Q into H, forming vacua in r and Q, as the little mercury-threads remaining in the side-tubes r_1 and s_1 form shut-off valves. As soon as the mercury has fallen below the entrance-point of S into E the pressure in R and Q become equal, the denser air flowing out through S into Q. The time during which Q is connected with R may be determined at will by changing the right ledge of the sliding weight. Then the balance again changes its position, the mercury rises in

V, and so on. When the pump has made a few strokes in this manner, a lever T is let down, so as to rest on the ledge *u*. The wheel F provided with six pegs is now turned a tooth farther each time the weight C slides from the left to the right, and the ledge-peg *f*, which when the lever was raised caught each time into a notch of the peg-wheel, rests for the length of five strokes of the pump against the circumference of the wheel, and does not catch into the notch until the sixth stroke. As the rising of the quicksilver in the pump is in the inverse proportion of the momentum of the counter-weight in its left final position, if the ledges and peg *f* are rightly placed, it will when ascending be driven five times into the little hollow space r_2 and only at the sixth into the ball *n*. In consequence of this the little air-bubbles are accumulated in the highly evacuated space r_1 in which they ascend owing to the slight counter-pressure, and forming larger bubbles, and having easily overcome the somewhat greater counter-pressure of the mercury column s_1 they rise into the ball P.

All these manipulations are performed *entirely automatically* by the apparatus. At the same time that the toothed wheel has commenced working (*i.e.* when the volume of air pumped out by the pump has sufficiently diminished) the vessel P is entirely cut off from the hydrostatic air-pump by the cock t_1, thus ceasing to act. The mercury of the pump is entirely shut off on *both sides* from the exterior air, and only in contact with perfectly *dry* air. After stopping the pump, concentrated sulphuric acid may be sucked up into P, which dries up entirely. The mercury is shut off from M by a caoutchouc bag, I.

The following experiments were made at the Physical Institute of the University of Berlin :

400 c.cm. (cubic centimetres) were evacuated to 1/1000 m.m. in ten minutes ; 4000 c.cm. = 4 litres, in an hour.

The highest rarefaction hitherto obtained has been about from 1/6000,00 – 1/800,000 m.m. = to about $\frac{1}{130000000} - \frac{1}{600000000}$ atmospheres.

The pump is supplied by Messrs. E. Leybolds Nachfolger, Cologne (Germany). AUGUST RAPS.

CRYSTALLISED CARBON.

IN the course of some researches on the properties and modes of formation of the various forms of carbon, M. Henri Moissan has succeeded in reproducing the variety of diamond known as *carbonado*, or black diamond, and has even obtained some minute crystals of the colourless gem. An account of his results in the *Comptes Rendus* of February 6 is followed by an article on the reproduction of the diamond, by M. Friedel, and some congratulatory remarks by M. Berthelot.

As long ago as 1880 Mr. Hannay[1] indicated the formation of diamond-like crystals on heating under high pressure, in a tube of iron, a mixture of lithium, lamp-black, essence of paraffin, and bone oil. It was then supposed that the nitrogenous compounds of the last substance played the most important part. In M. Moissan's new process carbon obtained from sugar is dissolved in a mass of iron, and allowed to crystallise out under high pressure. To produce this pressure the expansion of iron during condensation is utilised. The carbon is strongly compressed in an iron cylinder closed with a screw-stopper of the same metal. A quantity of soft iron, weighing about 150 or 200 gr., is melted in the electric furnace in a few minutes, and the cylinder is plunged into the molten mass. The crucible is at once taken out of the furnace and splashed over with water. When the external crust is at a red heat the whole is allowed to cool slowly in air.

The metallic mass thus obtained is attacked by boiling hydrochloric acid until all the iron is removed. There remain three forms of carbon: graphite in small quantity; a chestnut-coloured carbon in very small needles, such as has been found in the Cañon Diablo meteorite; and a small quantity of denser carbon which has to be further isolated. For this purpose the mixture is treated alternately with boiling sulphuric and hydrofluoric acids, and the residue decanted in sulphuric acid of density 1·8. It then contains only very little graphite, and various forms of carbon. After six or eight treatments with potassium chlorate and fuming nitric acid, the residue is boiled in hydrofluoric acid and decanted in boiling sulphuric acid to destroy the fluorides. It is then washed and dried, and bromoform is employed to separate out some very small fragments denser than that liquid, which scratch the ruby, and, when heated in oxygen at 1000°, disappear.

Some of these fragments are black, others transparent. The former have a rough surface, and a greyish black tint identical with that of certain carbonadoes; they scratch the ruby, and their density ranges from 3 to 3·5. Some pieces have a smooth surface, a darker colour, and curved edges. The transparent fragments, which appear broken up into small pieces, have a fatty lustre, are highly refractive, and exhibit a certain number of parallel striæ and triangular impressions.

During combustion in a current of oxygen at 1050°, some of the fragments left cinders of an ochreous colour, usually preserving the original form of the small crystal—just as in the combustion of impure diamonds.

As indicated already by Mr. Sidney Marsden,[1] silver heated to 1500° in presence of sugar carbon is found to contain on cooling some black crystals with curved edges. M. Moissan has found that high pressure is indispensable. He heated silver till it boiled briskly in contact with carbon, and found that a certain quantity of the latter was dissolved. By suddenly cooling in water, a portion of liquid silver, cooling inside a solid crust, was subjected to a very high pressure. No diamonds were formed, but rather a large crop of carbonadoes of densities ranging from 2·5 to 3·5, thus forming a series connecting graphite with diamond. Bromoform separated a carbonado, which scratched the ruby and burned in oxygen at 1000°. A quantitative determination of this reaction showed that 0·006 parts of this substance gave 0·023 of carbonic acid.

M. C. Friedel describes an experiment in which he obtained a black powder capable of scratching corundum by the action of sulphur on molten iron containing 4 per cent. of carbon. But the question of the production of diamond powder by this means is as yet an open one.

M. Moissan is continuing his researches on the solubility of carbon in iron, silver, and their alloys. It is to be hoped that he will soon be able to exhibit artificial true diamonds of a more imposing size.

LINES OF STRUCTURE IN THE WINNEBAGO CO. METEORITES AND IN OTHER METEORITES.[2]

THE ground and polished surface of a Winnebago Co. meteorite showed to me some interesting markings. Subsequent examination revealed like markings in other meteorites. Perhaps these markings have been described. If so I have no recollection of the description, and therefore it seems worth while to call attention to them.

The polished surface of a small Winnebago stone, three or four square centimetres in area shows several hundreds of bright metallic points. The larger iron particles in this surface have great varieties of shapes—the smaller

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[1] Proc. Roy. Soc., vol. xxx. p. 188.

[1] Proc. Roy. Soc. Ed. 1880, vol. ii. p. 20.

[2] Reprinted from the February number of the *American Journal of Science*.